Recurrent Lumbar Disc Herniation After Conventional Discectomy

A Prospective, Randomized Study Comparing Full-endoscopic Interlaminar and Transforaminal Versus Microsurgical Revision

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Study Design: Prospective, randomized, controlled study of patients with recurrent lumbar disc herniations after conventional discectomy, operated either in a full-endoscopic or microsurgical technique.

Objective: Comparison of results of lumbar revision discectomies in full-endoscopic interlaminar and transforaminal technique with the conventional microsurgical technique.

Summary of Background Data: Recurrences after lumbar disc operations cannot be prevented. Because of the existing scarring, the risk of intraoperative complications may be increased and consecutive damage may arise owing to greater traumatization. In disc surgery, tissue-sparing interventions are becoming more widespread. Endoscopic techniques have become the standard in many areas because of the advantages they offer intraoperatively and postoperatively. With the transforaminal and interlaminar techniques, 2 full-endoscopic procedures are available for the lumbar spine.

Methods: Eighty-seven patients with recurrent herniation after conventional discectomy underwent full-endoscopic or microsurgical intervention and were followed for 2 years. In addition to general and specific parameters, the following measuring instruments were used: visual analog scale, German version of the North American Spine Society Instrument, Oswestry Low-Back Pain Disability Questionnaire.

Results: Postoperatively, 79% of the patients no longer had leg pain, and 16% had occasional pain. The clinical results were the same in both groups. The re-recurrence rate was 5.7% with no difference between the groups. The full-endoscopic techniques brought significant advantages in the following areas: rehabilitation, complications, and traumatization.

Conclusions: The clinical results of the full-endoscopic technique are equal to those of the microsurgical technique. At the same time, there are advantages in the operation technique and reduced traumatization. With the surgical devices and the possibility of selecting an interlaminar or posterolateral to lateral transforaminal procedure, recurrent lumbar disc herniations can be sufficiently removed using the full-endoscopic technique. Full-endoscopic surgery is a sufficient and safe supplementation and alternative to microsurgical procedures.

Key Words: recurrent lumbar disc herniation, disc herniation, lumbar discectomy, endoscopic discectomy, endoscopic nucleotomy, minimally invasive spine surgery

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Recurrences after operations of disc herniations using only sequestrotomy or diskectomy cannot be prevented. The rate of recurrence is reported variously in the literature and depending on anulus defect and fragment type ranges from 5% to over 20%.[1–6] Sometimes, the results of revisions are rated worse than in the primary operation, which is attributed among other things to the epidural scarring, progradient degeneration with stenosis, arachnoiditis, segmental instability or traumatization owing to the operation.[7–12] Epidural scarring may lead to an increased risk of injury to the dura or nerves.[12–15] Greater traumatization with possible consecutive sequelae can be necessary.[16–23] For this reason, tissue-sparing techniques are used.[24,25] The goal of a new procedure must be to achieve results commensurate with current results[26] while minimizing traumatization and its negative long-term consequences. Technical advances have been made in the primary operation of disc herniations which these days enable a full-endoscopic technique and may provide the advantages of a truly minimally invasive procedure.[27–35]

The open interlaminar access has been described in spine surgery since the early 20th century.[36–39] Percutaneous operations have been performed since the early

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1970s.[40–42] In the late 1970s, a microsurgical procedure involving a microscope was developed to gain interlaminar access.[43–46] The full-endoscopic transforaminal operation with posterolateral access evolved out of this.[47–54] Endoscope-assisted interlaminar procedures were reported in the literature in the late 1990s.[55–59] The lateral access in full-endoscopic transforaminal surgery has been performed since the late 1990s.[32] The development of the full-endoscopic interlaminar access was seen at the same time.[31,33]

Minimally invasive techniques can reduce tissue damage and its consequences.[59–61] Endoscopic operations have become standard in various areas, such as arthroscopy or laparoscopy. The most widely used full-endoscopic procedure in patients with lumbar disc disease is transforaminal surgery with posterolateral appoach.[47,48,50,51,53,54,62] Removal of the intraforaminal or extraforaminal sequestered material is technically possible.[62,63] Resection of the sequestered nucleus pulposus material within the spinal canal has been described.[47,48,54,64] Nonetheless, difficulty in achieving an adequate resection of herniated discs within the spinal canal cannot always be excluded.[32,48,65] With the lateral approach, the spinal canal can be reached more sufficiently under continuous visualization.[28,30,32] But the osseous perimeter of the foramen and the exiting nerve can limit the working mobility and excision of dislocated herniated material.[28,30,32,48] Moreover, the pelvis and the abdominal structures may block access. Thus, there can be limitations to the transforaminal procedure.[28,30,32] The full-endoscopic interlaminar access has been developed to enable the extirpation of pathologic entities not successfully achieved using the transforaminal technique.[28,30,31,33]

The goal of this prospective, randomized, controlled study was to compare the revision results of recurrent lumbar disc herniations after conventional discectomies in full-endoscopic technique via interlaminar and transforaminal approach with those of the conventional microsurgical technique.

MATERIALS AND METHODS

Patient Characteristics

In the prospective, randomized, controlled study, we enrolled 100 patients with clinically symptomatic recurrent disc herniation after conventional discectomies who underwent surgical treatment in 2004/2005. All of the patients came to the hospital on an emergency basis because of their complaints or were referred by other doctors to the hospital to determine the further therapy procedure. There were 44 female and 56 male patients whose age ranged from 23 to 59 years (mean 39 y). The duration of pain ranged from 1 day to 13 months (mean 69 d). Seventy-nine patients had received a mean of 9 weeks of conservative treatment. The mean time between the primary operation and revision was 19 months (2 to 82 mo). The indication for surgery was defined according to present-day standards based on radicular pain symptoms and existing neurologic deficits.[66,67]

Study Groups

Fifty patients each underwent conventional microsurgical (MI) or full-endoscopic (FE) [21 × transforaminal (TF), 29 × interlaminar (IL)] revision discectomy. Randomization was open, because the patients may identify the operation procedure. After determination of the general indication for disc surgery by experienced physicians who were not involved in the operation, randomized assignment was made by nonphysician study staff alternately to the MI or FE group in the sequence of presentation. The surgeon in each case selected the access within the FE group. All operations were performed by 2 surgeons, who have many years of experience in both the techniques.

Thirty-eight interventions were performed at the L5-S1 level (21 × MI, 0 × TF, 17 × IL), 42 at L4-5 (18 × MI, 15 × TF, 9 × IL), 16 at L3-4 (10 × MI, 4 × TF, 2 × IL), and 4 at L2-3 (1 × MI, 2 × TF, 1 × IL).

Inclusion Criteria

Patients were enrolled who had undergone previous conventional discectomy, presented with acute occurrence of radicular leg symptoms on the same side after a pain-free interval and who showed a recurrent disc herniation in the same level in a magnetic resonance imaging with contrast medium. All forms of recurrent disc herniations located inside the spinal canal were included in the study and randomly assigned to the MI or FE group. There were no intraforaminal or extraforaminal herniations in the collective.

All disc herniations in the MI group were operated under paramedian interlaminar access.

In the FE group, the transforaminal technique was access of choice owing to the known lower traumatization when the disc herniation fulfilled the indication for this technique. When the criteria were not fulfilled, the interlaminar access was used. On the basis of our earlier experience with limited technical mobility,[28,30,32] we applied the following inclusion criteria for the full-endoscopic transforaminal access: (1) sequestering of material located cranially below the lower edge of the cranial pedicle or caudally not over the middle of the caudal pedicle: and (2) lateral radiologic evidence that the foramen was not overlaid by the pelvis beyond the middle of the cranial pedicle.

The inclusion criteria for the full-endoscopic interlaminar access were the disc herniations, which in our experience were technically difficult to treat using the transforaminal technique given the aforementioned criteria.

Operative Technique

The conventional microsurgical operations were performed with paramedian access in known standardized technique using a microscope.

The full-endoscopic transforaminal procedure was performed with access as lateral as possible in the

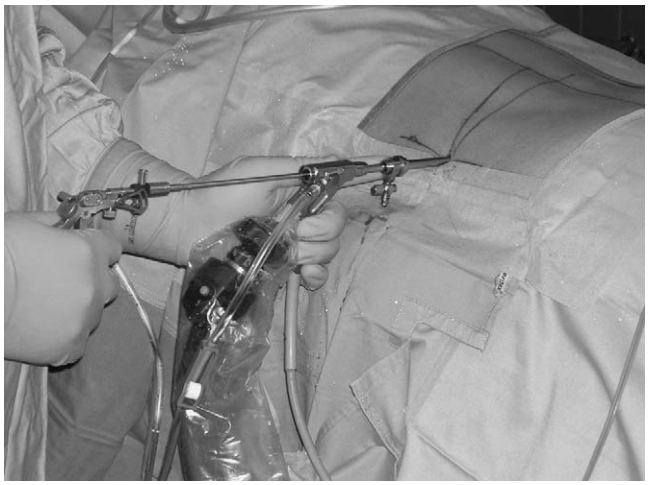

FIGURE 1. Lateral approach for the full-endoscopic transforaminal operation.

technique described earlier.[28,30,32] An atraumatic spinal cannula is inserted via the 6 mm skin incision. After insertion of a lead wire, the cannulated dilator is pushed in. Then a surgical sheath with beveled opening is placed. Thereafter, decompression is performed while maintaining visual control and constant irrigation (Fig. 1). If the anatomic osseous diameter of the intervertebral foramen does not permit direct entry into the spinal canal, the opening is expanded using burrs. An extraforaminal approach is made at the caudal pedicle in cases where the position of the exiting nerve is not clear.

The full-endoscopic interlaminar operation was performed in the technique described earlier.[28,30,31,33] A dilator is inserted bluntly to the lateral edge of the interlaminar window and an operation sheath with beveled opening directed toward the ligamentum flavum. Thereafter, the procedure is performed under visual control and constant irrigation (Fig. 2). The medial edge of the descending facet is located and prepared directly on the bone toward ventral until the medial edge of the ascending facet is visible. Directly at the bone, blunt penetration to the floor of the spinal canal and preparation of the ventral epidural space. Bone resection to expand the interlaminar window to enable penetration into the spinal canal with the endoscope is usually not necessary owing to the resection during the primary operation.

The operation was performed in all groups under general anesthesia. Drainage was applied only in the MI group. Sequestrotomy alone was performed in small or covered anular defects when the sequestered disc material has exceeded the level of the intervertebral space toward cranial or caudal ($3 \times$ MI, $5 \times$ FE).

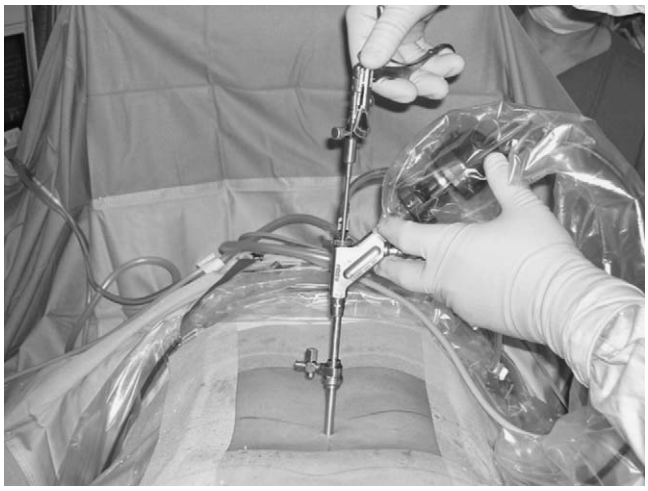

FIGURE 2. Interlaminar approach for the full-endoscopic operation.

Full-endoscopic Instruments

The rod-lens optics has an outer diameter of 6.9 mm. The optics contains an intraendoscopic, excentric working canal with a diameter of 4.1 mm. The angle of vision is 25 degrees. The working sheaths used have an outer diameter of 7.9 mm and a beveled opening, which enable creation of visual and working fields in an area without clear anatomically preformed cavity. All of the operating instruments and optics were products supplied by WOLF (Richard Wolf GmbH, Knittlingen, Germany) (Fig. 3).

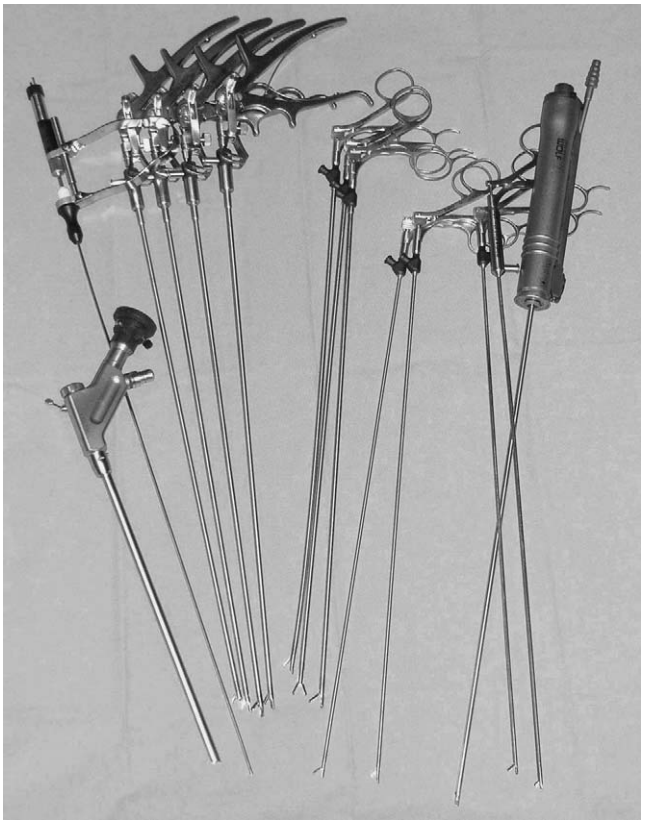

FIGURE 3. Various instruments are available which are known in similar, larger form in conventional surgery.

Follow-up

Follow-up examinations were conducted at Day 1 (100 patients) and at months 3 (96 patients), 6 (91 patients), 12 (90 patients), and 24 (87 patients) after surgery. All patients received the appropriate questionnaire by mail 4 working days in advance. They came personally to the clinic for follow-up examination. The examinations were performed by 2 doctors in the clinic, who were not involved in the operations. In addition to general parameters, other information was obtained using the following instruments: a visual analog scale (VAS) for back and leg pain, the German version of the North American Spine Society Instrument (NASS),[68,69] and the Oswestry Low-Back Pain Disability Questionnaire (ODI).[70]

Statistical Analysis

The Wilcoxon rank-sum test and the Mann-Whitney *U* test were applied for the comparison of preoperative and postoperative global results and comparison of results in the MI versus the FE group at various times. The McNemar test was used to compare the characteristics of the groups. The descriptive assessments and analytical statistics were performed depending on the group characteristics with the program package, SPSS. A positive significance level was assumed at probability < 0.05.

RESULTS

Baseline Characteristics

Eighty-seven (87%) patients were included in the follow-up after 2 years [$42 \times$ MI, $45 \times$ FE ($21 \times$ TF, $24 \times$ IL)]. The remaining cases were lost for the following reasons: 1 patient moved away and left no forwarding address, 7 patients did not respond to letters or telephone calls, 3 patients underwent revision surgery with conventional spinal canal decompression, and 2 underwent fusion. The patient population was equal in the MI and FE groups. Overall, there were no differences in results in dependence on the individual surgeons.

Operative Technique

The operation time was measured from the skin incision to the end of wound closure. In the FE group it was 24 minutes (14 to 43), and thus significantly shorter ($P < 0.001$) than in the MI group at 58 minutes (39 to 91). There were no significant differences within the FE group (TF, 14 to 33; IL, 18 to 43 min). The general preparation before and after the operation was the same in all groups, so that no time differences arose in this respect. The mean intraoperative and postoperative blood loss was 41 mL (10 to 205) in the MI group; there was no measurable blood loss in the FE group.

Complete removal of sequestered disc material seemed technically possible based on intraoperative control in combination with the clinical results in both the groups. Nonetheless, it cannot be entirely ruled out that portions of the sequester may remain.

Access-related osseous resection was required in 47 cases (94%) in the MI group and in 3 cases (6%) in the FE group ($2 \times$ TF = 9.5%, $1 \times$ IL = 3.4%) ($P < 0.001$).

Extirpation of the intervertebral space was made 42 times ($47 \times$ MI, $45 \times$ FE), because the recurrence was at the level of the intervertebral space and there was an uncovered anulus defect.

The patients in the FE group were mobilized directly postoperative depending on the effect of the anesthesia.

Perioperative Complications and Revisions

There were 4 (4%) cases of dura injury [$3 \times$ MI (6%), $1 \times$ IL (2%)], 2 of which were glued ($1 \times$ MI, $1 \times$ IL) and 2 sutured ($2 \times$ MI). No nerve injury or Cauda-equina syndrome was observed. Seven patients developed a transient postoperative dysesthesia ($5 \times$ MI, $2 \times$ IL), 2 patients developed transient urinary retention ($2 \times$ MI). In the MI group, 2 patients suffered delayed wound healing and 1 patient a soft-tissue infection. There were no other complications like spondylodiscitis or thrombosis.

Three patients were revised later owing to persistent leg pain by means of more extensive conventional spinal canal decompression ($1 \times$ MI, $2 \times$ FE), 2 patients underwent additional fusion owing to progradient back pain ($2 \times$ MI).

Overall, the rate of serious complications was 14% (21% MI, 6% FE) and was significantly increased in the MI group ($P < 0.05$).

Re-recurrences

Differentiation was made between 2 types of disc damage: small or covered anular defects and large anular defect. Overall, re-recurrence was observed in 5 patients (5.7%) [$2 \times$ MI = 4.8%, $3 \times$ FE = 6.7% ($2 \times$ TF, $1 \times$ IL)]. There were no significant differences. One recurrence was in the group with small anular defect, 4 in the group with large anular defect. All patients were reoperated in the same technique as before. The mean operation time in revisions was 56 minutes in the MI group and 26 minutes in the FE group. These re-recurrences consisted histologically to more than 75% of endplate material.

Clinical Outcome

Figures 4–7 show VAS pain scores, ODI scores, and NASS scores. There is constant and significant ($P < 0.001$) improvement in leg pain and daily activities in all groups. After 2 years, 69 (79%) patients no longer had leg pain ($32 \times$ MI = 76%, $37 \times$ FE = 82%), 14 (16%) had pain occasionally or the pain was greatly reduced ($7 \times$ MI = 17%, $7 \times$ FE = 16%), and 4 (5%) experienced no essential improvement ($3 \times$ MI = 7%, $1 \times$ FE = 2%) (Fig. 8). The differences in results between the groups were not significant. Five patients suffered progradient back pain [$4 \times$ MI, $1 \times$ FE ($P < 0.01$)].

Overall, 5 patients (5.4%) ($3 \times$ MI, $2 \times$ FE) underwent revision with decompression (3) and with additional

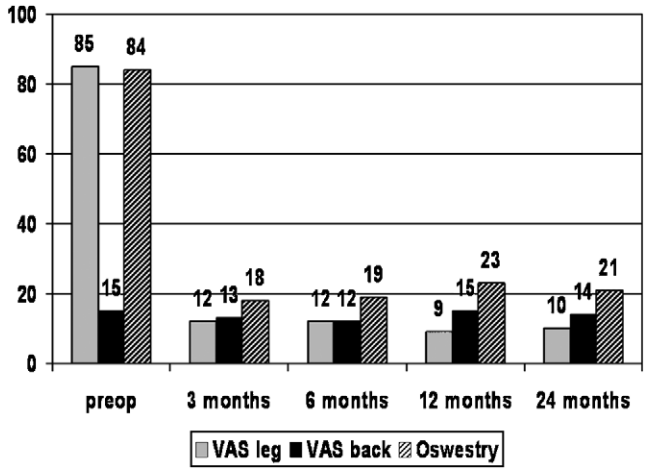

FIGURE 4. Mean values of visual analog pain scale for leg and back and Oswestry in the microsurgical group.

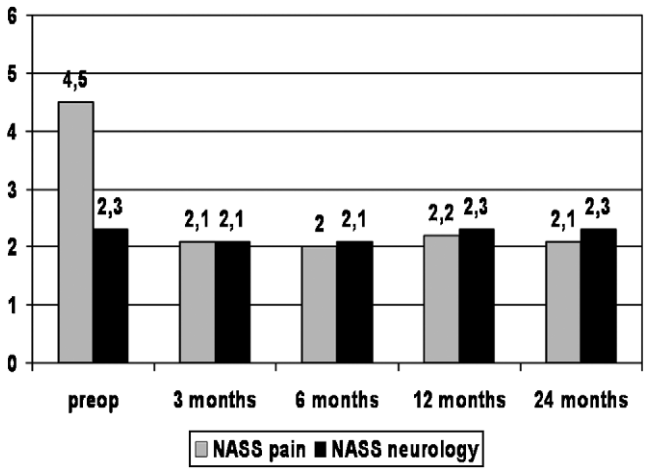

FIGURE 6. Mean values of North American Spine Society (NASS) pain and neurology in the microsurgical group.

fusion (2). Neurologic deficits were significantly ($P < 0.001$) reduced when the patient's history of weakness was less than 10 days.

Seventy-nine (91%) patients reported subjective satisfaction and would undergo the operation again ($36 \times MI = 86\%$, $43 \times FE = 95\%$). Overall, 9 patients had a poor result in terms of no leg pain reduction (4 patients) or had to undergo conventional revision surgery later for persistent leg or back pain (5 patients). Counting the re-recurrences, a total of 10 (11%) of 92 patients underwent revision ($5 \times MI$, $5 \times FE$).

Postoperative pain and pain medication were significantly reduced in the FE group ($P < 0.01$). The mean postoperative work disability in the FE group was 28 days versus 52 days in the MI group ($P < 0.01$).

DISCUSSION

In operation of lumbar disc recurrences, the risk of injury to dura and nerves may increase owing to existing epidural scarring.[12–15] To minimize this, greater traumatizations with possible sequelae must often be accepted. Increased scarring of the epidural space may be problematic,[71–75] which may become clinically symptomatic,[72,73,75] make revisions more difficult, and lead to "tethering" of the Cauda equina by postoperative connection between the epidural space and paravertebral musculature.[76–80] Resection of stability preserving structures can promote operation-induced segmental instability.[16–23] The route of access in the innervation area of the dorsal branch of the spinal nerves can have a negative influence on the stabilizing and coordination system.[15,74,81] For this reason, attempts are made even in the primary operation, and also in revisions, to work with tissue-sparing techniques.[24,25,28,30–33,82]

Technical advances have been made in the operation of primary lumbar disc herniations which these days enable a full-endoscopic procedure under continuous irrigation in nearly all cases and which can provide the advantages of a truly minimally invasive procedure.[28,30–33] Parameters such as the osseous diameter of

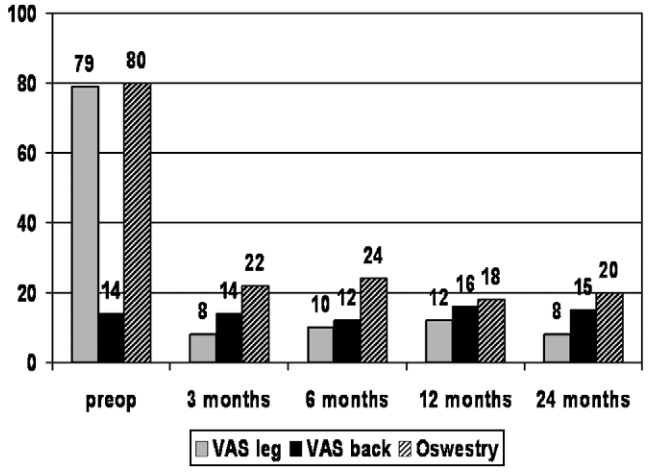

FIGURE 5. Mean values of visual analog pain scale for leg and back and Oswestry in the full-endoscopic group.

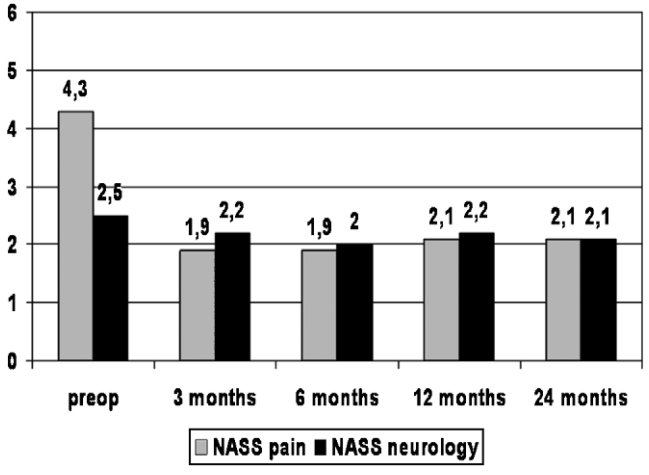

FIGURE 7. Mean values of North American Spine Society (NASS) pain and neurology in the full-endoscopic group.

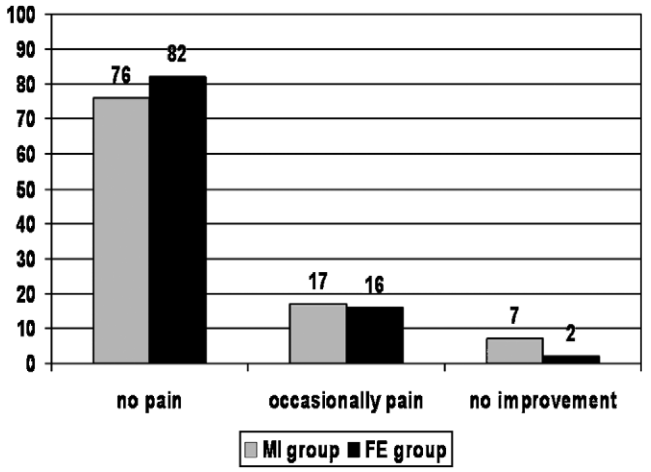

FIGURE 8. Clinical results in percent in the microsurgical and full-endoscopic group.

the interlaminar window and intervertebral foramen or the extent of sequestering of the disc material are no longer contraindications.[28,30–33] Thus all prerequisites are fulfilled for full-endoscopic performance of revision operations.

The mean operation time in the FE group of 24 minutes was significantly shorter than in the MI group with a mean of 58 minutes. No blood loss was observed in the FE group, no drainage was required. The necessity of resection stabilizing structures was significantly reduced in the FE group. The transforaminal access offers particular advantages, because the epidural scarring in the previous access area is circumvented. The reduction in operation time, traumatization, and operation-related sequelae in the FE group is also found in comparison to the literature.[14,83–86] Although all patients underwent surgery after the induction of general anesthesia in the present study, the use of local anesthetic is also possible.[54,62]

Studies of endoscopic transforaminal primary discectomies discuss various operating techniques and indication criteria, but describe good clinical results.[24,28,30,32,47–49,54] The same results are reported for the full-endoscopic interlaminar operation.[28,30,31,33] In the present study, the clinical results 2 years after the full-endoscopic operation were comparable to those of the microsurgical technique and correspond to the data reported in the literature.[7–12,24,87–89] This has been taken as the minimum prerequisite for new techniques. A significant and constant improvement was achieved in the MI and FE groups after 2 years without significant differences. Postoperative pain, pain medication, and work disability were significantly reduced in the FE group. When resection of spinal canal structures is avoided or the extent reduced, the minimally traumatic disc resection seems capable of reducing operation-induced consequences.[17,75,90–98] The complication rate of 6% in the FE group was significantly reduced compared with the 21% in the MI group. The rate of re-recurrent disc herniations was 5.7% and showed no significant differences. The rate corresponds to data in the literature.[1–4,99] The results of all these parameters in a literature comparison also favor the FE group.[14,83,85,91,97,100,101]

The goal of surgical treatment of recurrent lumbar disc herniations is sufficient decompression with minimization of operation-induced traumatization and its consecutive sequelae. Overall, no disadvantages were found in this study in using the full-endoscopic technique. At the same time, there are advantages in the operation technique and minimally invasive procedure around the access and the spinal canal structures.

With the surgical devices and the possibility of selecting an interlaminar or posterolateral to lateral transforaminal procedure, recurrent lumbar disc herniations can be sufficiently removed using the full-endoscopic technique, when taking the appropriate criteria into account. We view full-endoscopic surgery as a sufficient and safe supplementation and alternative to microsurgical procedures. This is a minimally invasive surgery technique for discectomy, which has long been a validated and established standard procedure. In our opinion, the following advantages are offered: facilitation for the surgeon owing to excellent visualization, good illumination, and expanded field of vision with 25-degree optics; cost-effective procedure owing to short operating time, rapid rehabilitation, and low postoperative costs of care; reduced anatomic trauma; facilitation of re-revision operations; monitor image as training basis for assistants. The following must be considered disadvantages: limited possibility of extending the approach in the event of unforeseen hindrances; in the transforaminal technique, the theoretically elevated risk of injury to exiting nerve; and difficult learning curve.

Attention must be paid especially to the last point of the demanding learning curve to avoid complications. Prior observation of/assisting at procedures and workshops with practice on cadavers could be meaningful. ''Simple'' cases, in which no difficulties are to be expected thanks to the anatomic situation, should be operated to begin with. The possibility of intraoperative switch to a standard procedure is helpful if problems are encountered.

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